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Proceedings of the Zonal Peer Review of the Northern and Striped Shrimp Assessment

February 16-17, 2017
St. John's, NL

Chairperson: K. Dwyer
Rapporteur: J. Pantin

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

The Zonal Peer Review Process for the Assessment of Northern and Striped Shrimp was held in St. John's, Newfoundland and Labrador (NL) February 16-17, 2017. The purpose of the meeting was to assess Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 5 and 6, and both Northern Shrimp and Striped Shrimp (*Pandalus montagui*) in SFA 4, the Eastern Assessment Zone (EAZ), and the Western Assessment Zone (WAZ).

The meeting was attended by staff from Fisheries and Oceans Canada (DFO) Science and Resource Management (Newfoundland and Labrador, Central and Arctic, and National Capital Regions), as well as participants from the fishing industry, the Provincial Department of Fisheries, Forestry and Agrifoods, academia, and Indigenous communities and organizations.

Detailed rapporteur's notes of the discussion that followed each presentation were produced. This Proceedings Report includes abstracts and summaries of meeting discussions, as well as a list of research recommendations. The meeting Terms of Reference, agenda, and list of participants are appended.

Compte rendu de l'examen zonal par les pairs – Évaluation de la crevette nordique et de la crevette ésope; du 16 au 17 février 2017

SOMMAIRE

Le processus zonal d'examen par les pairs pour l'évaluation des stocks de la crevette nordique et de la crevette ésope a eu lieu à St. John's, à Terre-Neuve-et-Labrador (T.-N.-L.), les 16 et 17 février 2017. L'objectif de cette réunion était d'évaluer la crevette nordique (*Pandalus borealis*) dans les zones de pêche de la crevette (ZPC) 5 et 6, ainsi que la crevette nordique et la crevette ésope (*Pandalus montagui*) dans la ZPC 4 et les zones d'évaluation est et ouest.

Les participants à la réunion étaient des employés du secteur des sciences et de la gestion des ressources de Pêches et Océans Canada (régions de Terre-Neuve-et-Labrador, du Centre et de l'Arctique, et de la région de la capitale nationale), ainsi que des participants de l'industrie de la pêche, du ministère provincial des Pêches, des Forêts et de l'Agroalimentaire, du milieu universitaire, ainsi que des communautés et des organisations autochtones.

Les notes détaillées du rapporteur des discussions qui ont suivi chaque présentation ont été produites. Ce compte rendu comprend un résumé et un sommaire des discussions de réunion, de même qu'une liste des recommandations relatives à la recherche. Le cadre de référence, l'ordre du jour et la liste des participants de la réunion sont joints.

INTRODUCTION

The Zonal Peer Review Process for the Assessment of Northern and Striped Shrimp was held in St. John's, Newfoundland and Labrador (NL) February 16-17, 2017. The purpose of the process was to assess Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 5 and 6, and both Northern Shrimp and Striped Shrimp (*Pandalus montagui*) in SFA 4, the Eastern Assessment Zone (EAZ), and the Western Assessment Zone (WAZ).

The meeting was attended by staff from Fisheries and Oceans Canada (DFO) Science and Resource Management (Newfoundland and Labrador, Central and Arctic, and National Capital Regions), as well as participants from the fishing industry, the Provincial Department of Fisheries, Forestry and Agrifoods, academia, and Indigenous communities and organizations.

This Proceedings Report includes abstracts of presentations and summaries of meeting discussions. Additional information can be found in the Science Advisory Report (SAR) or from references cited therein.

PRESENTATIONS

BIOLOGICAL AND PHYSICAL OCEANOGRAPHY OVERVIEW

Presenters: E. Colbourne and G. Maillet

Abstract

The North Atlantic Oscillation (NAO) Index, a key indicator of the direction and intensity of the winter wind field patterns over the Northwest Atlantic, remained in a positive phase during 2016; however, it was lower than in 2015. In addition, the spatial patterns of the associated atmospheric pressure fields resulted in a reduced arctic air outflow in the northwest Atlantic during the winter months. This resulted in higher than normal winter air temperatures in many areas. Sea ice extent, although above normal during March and April, was below normal overall during 2016.

Annual sea-surface temperature (SST; based on infrared satellite imagery) trends on the northeast Newfoundland Shelf, while showing an increase of about 1°C since the early 1980s, were mostly below normal during 2016. The annual bottom (176 m) temperature/salinity at the inshore monitoring station (Station 27) was below normal by -0.7/-1.4 SD, respectively in 2016. The cold-intermediate layer (CIL; volume of < 0°C) during 2016 was below normal off southern Labrador (Div. 2J), but above normal on the northeast Newfoundland Shelf (Div. 3KL). The spatially averaged bottom temperature in Divs. 2J and 3K show an increasing trend since the early 1990s of about 1°C, reaching a peak of > 2 SD above normal in 2011 and remaining above normal in 2016.

A standardized composite climate index for the Northwest Atlantic derived from meteorological, ice and ocean temperature and salinity time series since 1950 reached a record low value in 1991. Since then it shows an increasing trend with mostly above normal values except for 2014 and 2015, the latter being the seventh lowest in 67 years and the lowest value since 1993. Data from 2016 show a return to above normal conditions.

Analyses show that > 80% of fishable biomass of shrimp during the fall surveys is associated with relatively warm/salty Labrador slope water in a temperature range of 2°- 4°C. The area of the bottom in this temperature range, referred to as the 'Shrimp Thermal Habitat Index'

increased to above normal values during the mid-1990s and have ranged from normal to above normal since then, with the 2016 value above normal in both 2J and 3K.

Ocean colour data provide good spatial and temporal coverage of near surface dynamics of phytoplankton over the northwest Atlantic. Ocean colour sub-regions ranging from the Northwest Atlantic Fisheries Organization (NAFO) Divs. 0B (Hudson Strait) to 3K (NE Newfoundland Shelf) show a decline in the intensity and duration of the spring bloom in recent years, with a notable reduction in the extent of the fall bloom. Evaluation of sea ice and thermal indices indicate significant influence on the magnitude and timing of the spring bloom from northern Labrador to the northeast Newfoundland Shelf.

The biomass of zooplankton based on survey data in Divs. 2J and 3K and dry weight analysis has declined in contrast to abundance suggesting a shift to smaller sizes of zooplankton. Changes in copepod abundance were also correlated with ocean climate conditions and Labrador Current transport. Exploration continues into the utility of the remote sensing data and derived metrics and survey plankton indices to investigate how changes in biogeochemical, ocean climate conditions and transport volumes impact the lower trophic levels. After nearly 20 years of biophysical monitoring in the NW Atlantic by the Atlantic Zone Monitoring Program (AZMP), the time series are becoming invaluable to our understanding of the main biophysical drivers and their potential impact to the lower trophic levels.

Discussion

There was a question regarding whether the 'Shrimp Thermal Habitat Index' has been analyzed as a driver for shrimp production. Thermal habitat has not been used in the shrimp production analysis.

There was a question regarding whether there was any information on the preferred prey of shrimp. This information is unknown.

There was some confusion over a summary of the ocean colour imagery results which stated that the ocean colour imagery from Divs. 0B+3K show a decline in the intensity and duration of the spring bloom in recent years, with a notable reduction in the extent of the fall bloom. This decline refers to recent years (2014-16) compared to the reference period (1998-2010). It was noted that the conclusion could change if the reference period was different.

NEWFOUNDLAND AND LABRADOR BIOREGION: AN UPDATE ON ECOSYSTEM STRUCTURE, TRENDS, AND TROPHIC INTERACTIONS IN RELATION TO NORTHERN SHRIMP IN NAFO DIVS. 2J3KL (AND 2H WHENEVER POSSIBLE)

Mariano Koen-Alonso, Pierre Pepin, Nadine Wells, Geoff T. Evans, Jennifer Mercer, and Denise Holloway

Presenter: M. Koen-Alonso

Abstract

In terms of ecosystem structure and trends in NAFO Divs. 2J3KL, the changes observed in the 1990s involved the collapse of the groundfish community, not just cod, and the increase in shellfish. Consistent signals of rebuilding of the groundfish community appeared in the mid-late 2000s. In the 2010s the total biomass showed a decreasing signal mostly linked to a reduction in shellfish; the dominance of groundfishes increased, and shellfish decreased. The finfish biomass has been relatively stable in 2010-15, but the 2016 survey is suggesting a downward trend. This trend is clearly evident to the south of 2J3KL; the Grand Bank (3LNO) total RV biomass has decreased nearly 40% since 2010-13. Recent increases in Northern cod imply a

higher dominance within groundfishes, but do not reflect the overall trend of the fish community. Overall, it appears that the conditions that led to the start of a rebuilding of the groundfish community have declined. This may be linked to the simultaneous reductions in capelin and shrimp availability, as well as other changes in ecosystem conditions (e.g. declines in zooplankton levels in recent years).

Further north, in NAFO Div. 2H, even though the RV survey time series is incomplete and the signal is not fully consistent, it appears that the overall biomass has decreased in 2015-16. This overall decrease has been driven by a decline in plank-piscivores (redfish). Unlike 2J3KL, the fish community in this Division remains highly dominated by shellfish (shrimp). Small and medium benthivores have declined in recent years, while large benthivores are on the rise. There is no clear trend among piscivores. This functional group is highly dominated by turbot, but cod appears to have increased in recent years. Unlike southern regions, the planktivores signal is dominated by oceanic species like lanternfishes and black herring. Although the signal for this functional group is noisy, it still shows very low biomass levels in the last couple of years. Within the context of a noisy time series, shellfish seems to be declining, or at least to be at a lower level than in the 2000s and early 2010s.

From a predation and impacts perspective, total food consumption by predators (medium and large benthivores, piscivores, and plank-piscivores fish functional groups) in 2J3KL have been relatively stable in 2011-2015, but showed indications of a decline in 2016. Since 1995, consumption of shrimp and capelin have been between 25-50% of the total food consumption by predators, however they only represented 14% in 2016. Predation on shrimp showed an increasing trend until 2011, and has decreased since. Predation mortality of shrimp increased rapidly in 2008-11, and decreased afterwards. Still, current predation level is around double of the level in the mid-1990s and early 2000s. The potential relative impact of fishing with respect to predation has been variable in the period from 1995-2016. It represented 5-15% of predation in 1995-97, it grew to be 35-84% in 2002-03, and since 2013 represents around 15-30% of the predation impact. From an ecosystem perspective, due to heavy predation on shrimp, fishing pressure could now be influencing stock declines much more than it did in previous years.

In summary, the build-up of shrimp was driven by a combination of favorable environmental conditions and reduced predation. Shrimp is an important forage species, and the trend in predation mortality in the near future is highly associated with the availability of alternative prey like capelin. Current ecosystem conditions suggest that low availability of shrimp and capelin may hinder groundfish recovery. Given current predation levels on shrimp, fishing pressure could now be influencing stock declines much more than it did in the past.

Discussion

In reference to Divs. 2J3KL, there was discussion surrounding the importance of capelin as a forage species. It was noted that the signal for capelin was extremely low in the last trawl survey and recruitment signals in the last few years have been poor. The magnitude of this effect is unclear. It was noted that the 3L capelin survey was not conducted last year due to vessel issues and that the bottom trawl used in the RV multispecies surveys is not optimal for catching planktivores such as capelin.

With regards to results presented on fishing versus consumption, there was a question as to what was driving the range of estimates. It was stated that it is driven by the different consumption models, as there is a range of consumption models used. It was noted that high or low sampling could affect these estimates and better diet sampling can narrow the uncertainty. Diet sampling in the spring commenced in 2013 and spring diets are not sampled in the northern survey areas.

There was discussion surrounding the seasonal variation in diets and whether this is captured in the analysis. Currently, stomachs are collected during the fall survey in Divs. 2HJ3KLNO and during the spring survey in Divs. 3LNOPs. The seasonal variation in diets can only be addressed with additional surveys. It was noted that a comparison of spring and fall diets for a few years was conducted (not presented in present process) and there was not as much difference in the diets as would be expected. It was noted that additional data would most likely only change the range of the consumption, not the highs and lows observed.

There was a question as to whether the Northern Shrimp stock is under complete top-down control and whether it would be possible to reverse the current decline in shrimp productivity and rebuild the stock. It is believed the stock is under complete top-down control and either more production or less predation would be needed to rebuild the Northern Shrimp stock. However, if all the production is being consumed, then there is no potential for growth. In order to allow rebuilding, there needs to be an alternative prey that will allow reduced predation pressure on shrimp. This is the case when capelin availability is high. There was a question regarding the level of capelin biomass required to generate surplus production of shrimp. It was explained that a dynamic model would be needed to address this question and it is not possible with the available information at this time, especially considering the absence of capelin survey data for 2016.

There was discussion surrounding the opposing objectives of rebuilding both Northern Shrimp and Northern Cod stocks; it appears impossible to accomplish increases in abundance of both species. It was stated that the overall goal should be sustainable and healthy fisheries of all stocks. Currently, projections indicate low capelin abundance in the short term and this, combined with low zooplankton production, results in a situation where the main engine for rebuilding cod stocks (i.e. capelin) is not doing well and other stocks are suffering as well. It was stated that there is a need to discuss trade-offs of these stocks in a meaningful way, which is the objective of ecosystem based management. It was noted that there is currently no forum for discussion about trade-offs.

A Production/Biomass (P/B) ratio constant of 1.7 is currently used in the analyses of predation mortality and production, and there was a question regarding the variation around this value. It was stated that the variation around the P/B ratio is unknown; however, an exercise was recently performed using estimated median consumption coming from the model added to RV survey data to try to calculate the equivalent of the P/B ratio (not presented in present Process) and the result was very close to 1.7. It is believed that the highest source of variability is not on the assumption of the P/B ratio.

There was discussion regarding a figure presented on shrimp predation mortality. There was increased predation pressure on shrimp in 2016, but intuitively this should not happen because there are less shrimp and with less shrimp one would expect less consumption on shrimp. The figure showed an increase in predation because there is not enough of the alternative prey available for the predators to compensate for the decrease in shrimp abundance. Therefore even though they consume less shrimp, it is still at quantities too high to maintain or decrease predation mortality. The key message is that not only are there less shrimp, but there are less alternative prey as well.

There was a question regarding the inclusion of marine mammals in the consumption model presented. Marine mammals are not currently included in this model; however, they have been investigated in the past. There are good consumption estimates available for harp seals and reasonable estimates available for other seals. Diet composition data are available for harp seals; however this pertains mostly to inshore seals. Some stable isotope and fatty acid studies have suggested crustaceans and capelin may comprise part of the diet of seals. There are

limited estimates of whale and dolphin abundance over time as these mammals have very large foraging grounds; however, there is no information available on whale and dolphin diet composition. It is estimated that the total food consumed per year by marine mammals in general is 8 million tonnes.

There was a question regarding the presence (abundance and timing) of cod in Div. 2H. It was stated that there has been a small amount of cod observed in the surveys each year; however, since 2012 there has been a higher presence of cod in this division.

SCIENCE ADVISORY REPORT (SAR) BULLETS FOR ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

It was noted that the purpose of the environmental and ecosystem presentations was to show how environmental conditions have changed, to provide some context prior to conducting the shrimp assessments.

There was discussion surrounding the addition of reference periods to the bullets to clarify what is considered 'normal.' The normal reference period for the Composite Climate Index, sea ice extent analysis, and fall bottom temperature analysis is 1981-2010.

There was a question regarding whether the relationships presented in the environmental and ecosystem considerations have been peer-reviewed. It was stated that the relationships between sea ice and the phytoplankton bloom and the phytoplankton bloom and shrimp productivity have been peer-reviewed in the primary literature (Fuentes-Yaco et al. 2007, Koeller et al. 2009); however, the ecosystem analyses have not been peer-reviewed. The ecosystem analysis research document is in progress. It was stressed by participants that the references for any peer-reviewed relationships should be cited in the SAR.

A participant asked about the relationship between the timing of the spring phytoplankton bloom and shrimp productivity. It was stated that the relationship presented was a correlation; however, it showed a very consistent pattern. It was suggested that the bullet concerning this analysis should state that the earlier bloom could lead to a further reduction in shrimp productivity in the short-term, instead of stating that it will lead to a further reduction.

There was discussion regarding the bullet that referenced the likelihood of rebuilding the Northern Shrimp resource in SFA 6 over the medium-term. There was reluctance to discuss the future as it is unclear what will happen. It was noted that the Precautionary Approach (PA) Framework does not refer to rapid rebuilding and that the guidelines state that the time frame and speed to rebuilding can take economics into consideration. It was suggested that an updated Integrated Fisheries Management Plan (IFMP) would provide guidance on this issue.

There was discussion surrounding a bullet highlighting the importance of shrimp as a forage species, particularly when capelin is scarce, and the expectation that shrimp predation mortality will remain high unless there is an increase in alternative prey abundance. A participant asked whether shrimp or capelin is more important as a forage species. It was stated that shrimp becomes an important forage species when capelin abundance is low. Another participant questioned how a statement could be made on 2016 capelin levels when a capelin survey was not conducted. Even though the DFO capelin survey was not conducted in 2016, there were lower levels of capelin in the RV survey, and beach and recruitment data suggest lower capelin levels. It was concluded that a comment on alternative prey should remain in the bullets.

ASSESSMENT OF SFA 6 NORTHERN SHRIMP

Presenter: K. Skanes

Abstract

A presentation was given on SFA 6 Northern Shrimp and was based on analysis of research survey and commercial data. The items presented included: total allowable catch, commercial catch to date, maps of fishery catch and effort, fishable biomass and abundance indices, female spawning stock biomass (SSB) and abundance indices, abundance indices at shrimp carapace length and updates to the PA Framework.

- TAC was reduced by 42%, to 27,825 t, from 2015/16 to 2016/17; however, it is uncertain if the TAC will be fully taken.
- The annual commercial CPUE has demonstrated a declining trend for about the last ten years.
- Commercial and survey data demonstrate a contraction of the resource within recent years.
- Fishable biomass index declined from 785,000 t in 2006 to 104,000 t in 2016, which is the lowest in the time series. There was a 25% decline between 2015 and 2016.
- Female spawning stock biomass (SSB) index declined from 466,000 t in 2006 to 65,000 t in 2016, which is the lowest in the time series. There was a 27% decline between 2015 and 2016.
- The exploitation rate index ranged between 5.5% and 21.4% from 1997 to 2016/17, and has averaged 17.8% in the last five years. The 2016/17 exploitation rate index will be 20.2% if the TAC is taken.
- The female SSB index is currently in the Critical Zone, of the Integrated Fisheries Management Plan (IFMP) Precautionary Approach (PA) Framework, with greater than 99% probability. If the 27,825 t TAC is maintained and taken in the 2017/18 season, the exploitation rate index will be 26.8%.
- The IFMP states that the exploitation rate should not exceed 10% while the female SSB index is in the Critical Zone.

Discussion

It was noted that data from the fall RV multispecies survey does not capture depletion. This is because there are not enough weeks of the survey in one location to calculate cumulative catch. The survey only samples each location once, whereas harvesters are fishing the same locations repeatedly year after year. Nevertheless, the data from the fall RV multispecies survey shows downward trends to support contraction of the resource (i.e. the biomass estimates by survey strata have been decreasing since 2006).

There was discussion surrounding industry perspectives of the current shrimp fishing season and past seasons. Last year harvesters experienced one week of very good catch rates; however, in the past catch rates seemed to be higher for longer. As well, last year the catch rates seemed to drop off very rapidly within two days. It was suggested by one participant that perhaps the shrimp are moving off the bottom when this occurs to avoid predators. It was noted that because of quota reductions and a change in sharing, this year the large vessel fleet is short of shrimp and consequently spending a lot of effort trying to catch a small quota in SFA 6. Industry participants reported very low catch rates for the current season in SFA 6 and a

concentration of fishing effort on the St. Anthony Basin. It was noted that the large vessel fleet would usually have caught a large portion of their quota by mid-February; however, they had only caught half of their quota by the same time in the current season.

One participant noted that previous SARs stated that the PA reference points were adjusted to reflect refinements to assessment methodology and requested that this be explained in detail in the Research Document.

SCIENCE ADVISORY REPORT (SAR) BULLETS FOR SFA 6

It was noted that the 2016 catch per unit effort (CPUE) point is subject to change as the observer data has not yet been received. However, the observer data only applies to large vessels.

One participant requested that data prior to 1996 be included in the assessment. It was stated that the data prior to 1996 cannot be used in the assessment as it was collected with a different gear and no comparative fishing analysis was conducted.

Clarification was requested for a proposed bullet stating that an analysis of weekly CPUE, cumulative catch, and cells fished indicates that there is a depletion of the resource in SFA 6. It was explained that there has been a reduction in high density patches and fishing down to smaller areas. There are now more cells with smaller catches than before, in addition to less cells fished. It was noted that contraction of the resource is an alarm signal on the state of the resource; nevertheless, the area covered by commercial fishing is greater than in the 1980s when it was harvested solely by large-vessel license holders.

There was a suggestion for a statement regarding the effect of no exploitation to highlight the environmental and ecosystem effects on the stock. It was stated that currently there is not a model to assess the effects of different exploitation rates and nothing can be said with certainty about the direction in which the stock is heading because it is unclear what is happening with capelin and cod. As well, it was noted that the future prospects of the stock will most likely come from the ecosystem analysis.

ASSESSMENT OF SFA 5 NORTHERN SHRIMP

Presenter: K. Skanes

Abstract

A presentation was given on SFA 5 Northern Shrimp and was based on analysis of research survey and commercial data. The items presented included: total allowable catch, commercial catch to date, maps of fishery catch and effort, fishable biomass and abundance indices, female spawning stock biomass and abundance indices, abundance indices at shrimp carapace length and updates to the PA Framework.

- TAC was increased by 10%, to 25,630 t, from 2015/16 to 2016/17.
- Standardized large-vessel CPUE over the last five years has been stable at relatively high levels.
- Fishable biomass index has decreased, by 27%, from 149,000 t in 2015 to 110,000 t in 2016.
- Female SSB index has decreased, by 35%, from 83,200 t in 2015 to 54,300 t in 2016.
- The exploitation rate index has varied without trend around 15% from 1997–2016/17.

- Female SSB index is in the Healthy Zone within the IFMP PA Framework, with a 6% chance of being in the Cautious Zone. If the 25,630 t TAC is maintained and taken in 2017/18, then the exploitation rate index will be 23.3%.

Discussion

It was reported that harvesters experienced opposite catch rates in SFA 5 as compared to SFA 6. Harvesters reported excellent catches in SFA 5 as opposed to the low catch rates in SFA 6, and were surprised that such a small proportion of the TAC had been caught.

It was noted that there is a greater abundance of multiparous (multiple spawning) females in SFA 5 and almost no transitional or primiparous (first-time spawning) females. However, this may be due to the timing of the fall survey. In the fall survey almost all of the females are ovigerous (egg-bearing) and cannot be identified as multiparous or primiparous when they are carrying eggs. The timing may not be correct for seeing primiparous females without eggs.

There was discussion surrounding a possible year effect in 2013, as the survey data resulted in a sharp decrease in the biomass and abundance indices for only that year. It was stated that this indicates that something different was happening in the community that year with respect to ecosystem interactions; not that there was necessarily a problem with the survey. It was noted that there was a spike in consumption of shrimp, led by redfish, that year.

ASSESSMENT OF SFA 4 NORTHERN AND STRIPED SHRIMP

Presenter: K. Skanes

Abstract

A presentation was given on SFA 4 Northern Shrimp and Striped Shrimp and was based on analysis of research survey and commercial data. The items presented included: total allowable catch, commercial catch to date, maps of fishery catch and effort, fishable biomass and abundance indices, female spawning stock biomass and abundance indices, abundance indices at shrimp carapace length and updates to the PA Framework for SFA 4 Northern Shrimp only.

SFA 4 Pandalus borealis

- TAC has remained the same, at 14,971 t, since 2013/14.
- Large-vessel standardized CPUE fluctuated without trend near the long-term mean.
- Between 2005 and 2012 the fishable biomass index ranged between 76,600 t and 164,000 t and in 2016 was 95,300 t.
- Between 2005 and 2012 the female SSB index ranged between 39,700 t and 115,000 t and in 2016 was 55,500 t.
- The exploitation rate index has been about 15% for the past three years.
- Female SSB index in 2016 was in the Healthy Zone within the IFMP PA Framework with a 45% probability of having been in the Cautious Zone.

SFA 4 Pandalus montagui

- Commercial catch of *P. montagui*, taken as by-catch in the *P. borealis* fishery, increased from 280 t in 2008 to 4,700 t in 2012 and declined to 1,092 t in 2016. The by-catch limit of 4,033 t has not been taken in the past four years.
- Fishable biomass index for 2016 was 23,900 t, a decrease of 49% from 2015.

- Female SSB is unknown.
- If the by-catch limit had been taken, the exploitation rate would have been 8.7% in 2016/17.
- There is no IFMP PA Framework for this resource.

Discussion

There was a question as to when the final data from 2016 will be available. It was stated that the observer data is usually received in October.

It was noted that quota transfers and double counting are not captured in catch reports in time for the assessment, which may affect the calculations of the percentage of the TAC taken.

With respect to Striped Shrimp in SFA 4, there was discussion regarding whether there was a decrease in the Female SSB index from 2015 to 2016 or whether it is just fluctuations over the years. It was decided that the fluctuating pattern would be mentioned in the text of the SAR.

SCIENCE ADVISORY REPORT (SAR) BULLETS FOR SFA 4

One participant noted that it is uncommon to see the Female SSB decrease and the fishable biomass index increase, as observed in SFA 4. It was discussed that it is difficult to determine if that pattern indicates strong recruitment. There was a question as to when the concept of a recruitment index was last investigated. An attempt at addressing a recruitment index was made 3-4 years ago and it was suggested that this become a research recommendation for the next assessment.

ASSESSMENT OF NORTHERN SHRIMP, *PANDALUS BOREALIS*, AND STRIPED SHRIMP, *PANDALUS MONTAGUI*, IN THE EASTERN AND WESTERN ASSESSMENT ZONES, FEBRUARY 2017

Authors: Wojciech Walkusz* and Sheila Atchison

*Presenting author

Abstract

The assessment includes the 2015 and 2016 survey and fishery data. In the WAZ, the 2014 survey began a new time series, not directly comparable with previous surveys because no trawl standardization between the DFO/Cosmos and Northern Shrimp Research Foundation (NSRF)-DFO/Campelen surveys has taken place. Because the time series is so short, trends cannot be inferred. In the WAZ, the resource is currently not assessed with an IFMP PA Framework. At least two additional surveys are needed prior to establishing the PA Framework. Survey biomass, fishery data, and fishery exploitation rate indices are used to assess *Pandalus borealis* and *Pandalus montagui*. In 2016, the near-bottom average water temperature (-0.4 °C) in the WAZ was the lowest in the survey time series.

Eastern Assessment Zone: Northern Shrimp Summary

- Total catch varied without trend around 6,000 t from 1997 through 2016/17. Catch statistics in 2016/17 are preliminary.
- The fishable biomass index varied without trend around the long-term mean (64,954 t) and was 65,570 t in 2016.
- The female SSB index varied without trend around the long-term mean (40,125 t) and was 34,827 t in 2016.

- The reported exploitation rate index for 2016/17 was 8.4% with 59% of the TAC taken. Based on the 2016/17 TAC of 9,488 t, the potential exploitation rate index was 14.5%.
- The resource is currently in the Healthy Zone within the IFMP PA framework.

Eastern Assessment Zone: Striped Shrimp Summary

- Total catch in 2016/17 was 213 t, 25% of the 840 t TAC. Catch statistics in 2016/17 are preliminary.
- The fishable biomass index varied without trend around the long-term mean (12,713 t) and was 13,792 t in 2016.
- The female SSB index varied without trend around the long-term mean (9,037 t) and was 10,056 t in 2016.
- The reported exploitation rate index for 2016/17 was 1.5% with 25% of the TAC taken. Based on the 2016/17 TAC of 840 t, the potential exploitation rate index was 6.1%.
- The status of the resource within the PA framework is uncertain due to the wide fluctuations in the female SSB index. As a result, caution is advised when setting the TAC.

Western Assessment Zone: Northern Shrimp Summary

- Total catch in 2016/17 was 641 t, which is 31% of the 2,080 t TAC. Catch statistics in 2016/17 are preliminary.
- The fishable biomass index declined from 28,532 t in 2015 to 13,116 t in 2016.
- The female SSB index declined from 14,710 t in 2015 to 8,015 t in 2016.
- The reported exploitation rate index for 2016/17 was 4.9% with 31% of the TAC taken. Based on the 2016/17 TAC of 2,080 t, the potential exploitation rate index was 15.9%.

Western Assessment Zone: Striped Shrimp Summary

- Total catch in 2016/17 was 6,071 t, which is 99% of the 6,138 t TAC. Catch statistics in 2016/17 are preliminary.
- The fishable biomass index was 55,194 t in 2015 and 31,724 t in 2016.
- The female SSB index was 27,324 t in 2015 and 18,691 t in 2016.
- The reported exploitation rate index for 2016/17 was 19.1% with 99% of the TAC taken. Based on the 2016/17 TAC of 6,138 t, the potential exploitation rate index was 19.3%.

Discussion

There was discussion regarding the methodology for producing error bars for biomass estimates. It was stated that EAZ/WAZ analyses use STRAP with bootstrap confidence intervals, while the SFAs 4-6 analyses use Ogmap with bootstrap confidence intervals. It was suggested that the assessment could benefit from a standardized methodology; however, it was noted that there is no standard methodology across Canada for stock assessments. It was stated that the entire time series would need to be re-analyzed if a new methodology were used. An analysis of the EAZ/WAZ data has been tried with Ogmap, but there were unresolved issues which had not been considered since. Prior to the development, peer-review and acceptance of Ogmap as a biomass estimation tool, STRAP was utilized for SFAs 4-6 shrimp.

There was a question regarding the rules for assigning stations for the NSRF survey in SFA 4 and the WAZ. It was confirmed that the stations are assigned in exactly the same way for both

areas of the survey. With respect to the WAZ, it was suggested that low biomass estimates may not equate to poor fishing, as environmental conditions could benefit fishing in that the shrimp may be congregating in a small area which makes them easier to catch. An industry perspective was offered noting that fishing was very good last year in the WAZ and there was a lot more Northern Shrimp bycatch. It was suggested that the fishing may be shifting greatly due to temperature changes and there was a suggestion to comment in the SAR specifically on the climate to reconcile the survey results and the fishing success.

SCIENCE ADVISORY REPORT (SAR) BULLETS FOR EAZ/WAZ

With respect to Northern and Striped Shrimp in the WAZ, there was discussion regarding inferring direction or trend from only three points. The biomass indices are calculated from survey data; however, the survey has been conducted by the NSRF since 2014, but was conducted by DFO prior to 2014. One participant suggested that it is too early to make recommendations because there is only comparable data since 2014. A bullet referring to the short time series was added to the summary/method bullets to emphasize this point.

It was stressed that the catch statistics in 2016/2017 are preliminary and it was deemed necessary that this statement be added to the bullets for the EAZ and WAZ.

DISCUSSION: TRIGGERS FOR INTERIM ASSESSMENTS

This topic was added to the agenda due to a response to the Auditor General of Canada's report on sustaining Canada's major fish stocks (Office of the Auditor General of Canada 2016). In the report, the Office of the Auditor General recommended that DFO should identify the indicators and values that would trigger a full assessment earlier than scheduled, for each major fish stock. An agreement was made that DFO would include this task in the Terms of Reference as each stock is assessed and report on whether the task was achieved. The Technical Expertise in Stock Assessment group (TESA - a DFO group that works on stock assessments) developed the guidelines for providing interim year updates and science advice for multiyear assessments (DFO 2016). The goal is to determine trigger values, that when crossed, will signal a change in stock status that may warrant a reassessment ahead of schedule or changes to management measures used for particular species or stocks. These indicators and trigger values must be clearly identified during a full peer-reviewed stock assessment process and documented in a peer-reviewed science advisory report.

With respect to the Northern Shrimp stocks, fishable biomass index, Female SSB index and exploitation rate are the indicators of stock status. The current assessment schedule for the Northern Shrimp stocks is a full assessment every two years and an assessment update in the interim years. TACs can be changed in full or update assessment years. There was discussion regarding the difference between a full assessment and an assessment update. It was noted that there is little difference between an update and a full assessment, as both include the same evaluation of indicators of stock status. The full assessment goes slightly further with the analyses by analyzing the commercial data and producing size frequencies. The results of a full assessment are published as a SAR and the results of an assessment update are published as a Science Response Report (SRR).

There were several trigger values suggested by participants; however, agreement could not be reached on which was appropriate for this stock. The following situations that could trigger a full assessment in interim years were suggested:

- A decline or increase in any stock status index greater than the largest decline or increase previously reported.

- A significant decline in Female SSB for a second year in a row.
- The Female SSB index falling under the Limit Reference Point (LRP) into the critical zone.
- It was noted that there are many Atlantic Canadian stocks in the critical zone that do not have full assessments every year. As well, it was stated that there is a difference between Female SSB being stable under the LRP and steadily declining under the LRP. Additionally, there is no PA Framework for the WAZ, and therefore it is not possible to determine when the Female SSB index falls below the LRP into the critical zone.
- The Female SSB index moving into a different zone or some probability that it is going to go into a different zone.
- It was noted that the Striped Shrimp stock in the EAZ moves in and out of the cautious zone from year to year and this suggested trigger value would result in a full assessment every year for this stock. As well, there is no PA Framework for the WAZ, and therefore it is not possible to determine what zone the Female SSB is in and if it moves to another zone. It was noted that for other Atlantic Canadian stocks, a NAFO assessment can be triggered early if a stock moved out of the critical zone; however, this is ad hoc decision making.

There was a general consensus that trigger values could not be identified for the shrimp stocks. It was noted that when doing the assessment update and the trigger is met, DFO would need to be able to respond quickly to switch to a full assessment. There was a suggestion that the trigger should be evaluated during the full assessment year, not right before the update, to ensure sufficient time to do the full assessment; however, it was countered that if the stock status indicators do not change the next year, then there would not be a need for another full assessment.

There was a consensus that if a trigger value (whatever it may be) is met for one SFA, then a full assessment would only be required for that SFA and assessment updates for the other SFAs.

There was discussion surrounding the difficulty in determining a trigger value that is appropriate for all stocks/management areas and all circumstances. As well, it was noted that very little is known about shrimp and therefore it is difficult to make projections. Consequently, it is unclear whether changes are drastic or not. It was also suggested that the magnitude of the stock must be considered, as not all stocks are equal in the eyes of the public. It is the magnitude of the impact on a particularly important stock that makes the public demand extra information (a full assessment in an update year) and it was suggested that there will be a lot of pressure from the industry and the public to have more information and a full assessment in 2017 for SFA 6 even though it will be an update year.

There was discussion regarding the appropriate forum for addressing this request. Some participants felt that determining trigger values for full assessments in interim years is a risk management issue that should be decided by managers, and it was also suggested that it is a discussion better suited for a Northern Shrimp Advisory Committee (NSAC) meeting. However, the request was presented to Science to address, not management, and has been addressed by Science for other stocks. It was suggested that CSAS could block off time for a full assessment each year that would only be used if the trigger value was met.

RESEARCH RECOMMENDATIONS

- Develop a model to predict the effect of different exploitation rates on the Northern Shrimp stocks.
- Investigate developing a recruitment index.
- Investigate the levels of uncertainty and undertake a sensitivity analysis for the [back of the envelope] ecosystem model in a peer-review process.
- Investigate the effects of fishing on production with respect to the timing of egg carrying, congregation and egg release.
- Investigate shrimp predation with respect to the importance of alternative prey.

REFERENCES CITED

DFO. 2016. Guidelines for providing interim-year updates and science advice for multi-year assessments. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/020.

Fuentes-Yaco, C., Koeller, P.A., Sathyendranath, S. and Platt, T. 2007. Shrimp (*Pandalus borealis*) growth and timing of the spring phytoplankton bloom on the Newfoundland-Labrador Shelf. Fish. Oceanogr. 16: 116-129.

Koeller, P., Fuentes-Yaco, C., Platt, T., Sathyendranath, S., Richards, A., Ouellet, P., Orr, D., Skúladóttir, U., Wieland, K., Savard, L. and Aschan, M. 2009. Basin-Scale Coherence in Phenology of Shrimps and Phytoplankton in the North Atlantic Ocean. Science. 324: 791-793.

Office of the Auditor General of Canada. 2016. Sustaining Canada's Major Fish Stocks – Fisheries and Oceans Canada. Reports of the Commissioner of the Environment and Sustainable Development. 31 p.

APPENDIX I: TERMS OF REFERENCE

Northern and Striped Shrimp Assessment

Zonal Peer Review - Newfoundland and Labrador, and Central and Arctic Regions

February 16-17, 2017
St. John's, NL

Chairperson: Karen Dwyer, Aquatic Resources, Science Branch, NL Region

Context

The status of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 4-6 and the Eastern and Western Assessment Zones, and Striped Shrimp (*Pandalus montagui*) in SFA 4 and the Eastern and Western Assessment Zones, is assessed on a biennial basis. In interim years, stock status updates are conducted.

The last Zonal Peer Review Process that assessed both Northern Shrimp in SFAs 4-6 and Striped Shrimp in SFA 4, and Northern and Striped Shrimp in the Eastern and Western Assessment Zones was held in February 2015 (DFO 2015). A stock status update for shrimp in the Eastern and Western Assessment Zones was held in January 2016 (DFO 2016a). The February 2016 update of Northern and Striped Shrimp in SFAs 4-6 (DFO 2016b) triggered a full assessment which was held in April 2016 (DFO 2016c).

Fisheries Management has requested the current assessment as the basis for harvest advice for the 2017/18 fishing season.

Objectives

- Assess indicators used to characterize stock status of Northern Shrimp in SFAs 4 to 6 (NAFO Div. 2G to 3K), as well as Striped Shrimp in SFA 4.
- Assess indicators used to characterize stock status of Northern and Striped Shrimp in the Eastern and Western Assessment Zones.
- For all areas, identify changes in indicators (i.e. trigger values) which would indicate that a full assessment may be warranted earlier than planned.

Expected Publications

- Science Advisory Reports
- Proceedings
- Research Documents

Participation

- DFO - Science and Fisheries Management Branches
- Government of Newfoundland and Labrador - Department of Fisheries, Forestry and Agrifoods
- Government of Nunavut
- Government of Nunatsiavut
- Aboriginal communities/organizations
- Academia

- Fishing Industry
- Other invited experts

References

DFO. 2015. 2015 Assessment of Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagui*, in the eastern and western assessment zones. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/017.

DFO. 2016a. Update of stock status indicators for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagui*, in the Western and Eastern Assessment Zones for 2016. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/006.

DFO. 2016b. Stock Status Update of Northern and Striped Shrimp in SFAs 4, 5 and 6. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/013.

DFO. 2016c. An assessment of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas 4-6 and of Striped Shrimp (*Pandalus montagui*) in Shrimp Fishing Area 4 in 2015. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/028.

APPENDIX II: AGENDA

Zonal Peer Review – Northern and Striped Shrimp Assessment

Chair: Karen Dwyer, Science Branch, DFO

February 14-16, 2017

Memorial Room - Northwest Atlantic Fisheries Centre
80 East White Hills Road, St. John's

Tuesday, February 14, 2017

Time	Activity	Presenter
9:00	Welcome/Opening	K. Dwyer (Chair)
-	Presentation: Biological and Physical Oceanography Overview	G. Maillet and E. Colbourne
-	Presentation: Ecosystem Considerations	M. Koen-Alonso
-	Presentation: Assessment of SFA 6 Northern Shrimp	K. Skanes
-	Drafting of Science Advisory Report (SAR) bullets for SFA 6	All

Wednesday, February 15, 2017

Time	Activity	Presenter
9:00	Presentation: Assessment of SFA 5 Northern Shrimp	K. Skanes
-	Drafting of SAR bullets for SFA 5	All
-	Presentation: Assessment of SFA 4 Northern and Striped Shrimp	K. Skanes
-	Drafting of SAR bullets for SFA 4	All

Thursday, February 16, 2017

Time	Activity	Presenter
9:00	Presentation: Assessment of Northern & Striped Shrimp in the EAZ/WAZ	W. Walkusz
-	Drafting of SAR bullets for EAZ/WAZ	All
-	Discussion: Summary Bullets and SARs	All
-	Discussion: Triggers for Interim Assessments	All
-	Research Recommendations	All
-	Upgrading of Working Paper	All
-	Closing/Next Steps	K. Dwyer (Chair)

APPENDIX III: LIST OF PARTICIPANTS

Name	Affiliation
Alastair O'Rielly	Northern Coalition
Annette Rumbolt	DFO – Resource Management, NL Region
Arnault Le Bris	Memorial University – Centre for Fisheries Ecosystem Research
Ben Davis	DFO – Science, NL Region
Bev Sheppard	Harbour Grace Shrimp Co.
Brian Burke	Nunavut Offshore Allocation Holders Association
Brian McNamara	Newfound Resources Ltd.
Brittany Beauchamp	DFO – Fish Population Science – National Capital Region
Bruce Chapman	Canadian Association of Prawn Producers
Dale Richards	DFO – CSA Office, NL Region
Darrell Mullowney	DFO – Science, NL Region
David Bonnell	Torngat Wildlife, Plants and Fisheries Secretariat
Derek Butler	Association of Seafood Producers
Derek Osborne	DFO – Science, NL Region
Don Stansbury	DFO – Science, NL Region (retired)
Dwight Russell	Harvester
Edgar Coffey	Quin-Sea Fisheries
Elizabeth Coughlan	DFO – Science, NL Region
Erika Parrill	DFO – CSA Office, NL Region
Eric Pederson	DFO – Science, NL Region
Erin Carruthers	Fish, Food and Allied Workers Union (FFAW)
Eugene Colbourne	DFO – Science, NL Region
Gary Maillet	DFO – Science, NL Region
Geoff Evans	Retired DFO – Science, NL Region
Gilbert Linstead	Labrador Fishermens Union Shrimp Co.
Jamie Goodyear	Harvester
Jennifer Duff	DFO – Communications – NL Region
Jim Meade	DFO – CSA Office, NL Region
John Furlong	Seawatch
Julia Pantin	DFO – Science, NL Region
Karen Dwyer	DFO – Science, NL Region & Meeting Chair
Katherine Skanes	DFO – Science, NL Region
Kathleen Martin	DFO – CSA Office, Central and Arctic Region
Keith Watts	Torngat Fish Producers Co-op

Name	Affiliation
Ken Budden	Fogo Island Co-op
Ken Fowler	Labrador Fishermens Union Shrimp Co.
Lon Mayne	Quin-Sea Fisheries
Leigh Edgar	DFO - Resource Management, National Capital Region
Mariano Koen-Alonso	DFO – Science, NL Region
Nancy Pond	Govt. of NL – Dept. of Fisheries, Forestry and Agrifoods
Nelson Bussey	Harvester
Nicolas LeCorre	Memorial University
Patrick Martin	Baffin Fisheries Coalition
Peter Shelton	DFO – Science, NL Region
Peter Rose	Makivik Corp.
Phil Barnes	Fogo Island Co-op
Phil Quinlin	Quinlin Taylor
Pierre Pepin	DFO – Science, NL Region
Ray Dalley	Quin-Sea Fisheries
Robyn Morris	Torngat Wildlife, Plants and Fisheries Secretariat
Roland Hedderson	Fish, Food and Allied Workers Union (FFAW)
Roy Ward	Harvester
Shawn Dempster	Harvester
Sheila Atchison	DFO – Science, Central and Arctic Region
Todd Broomfield	Nunatsiavut Government
Tom Dooley	Govt. of NL – Dept. of Fisheries, Forestry and Agrifoods
Travis Jacobs	Fogo Island Co-op
Wojciech Walkusz	DFO – Science, Central and Arctic Region